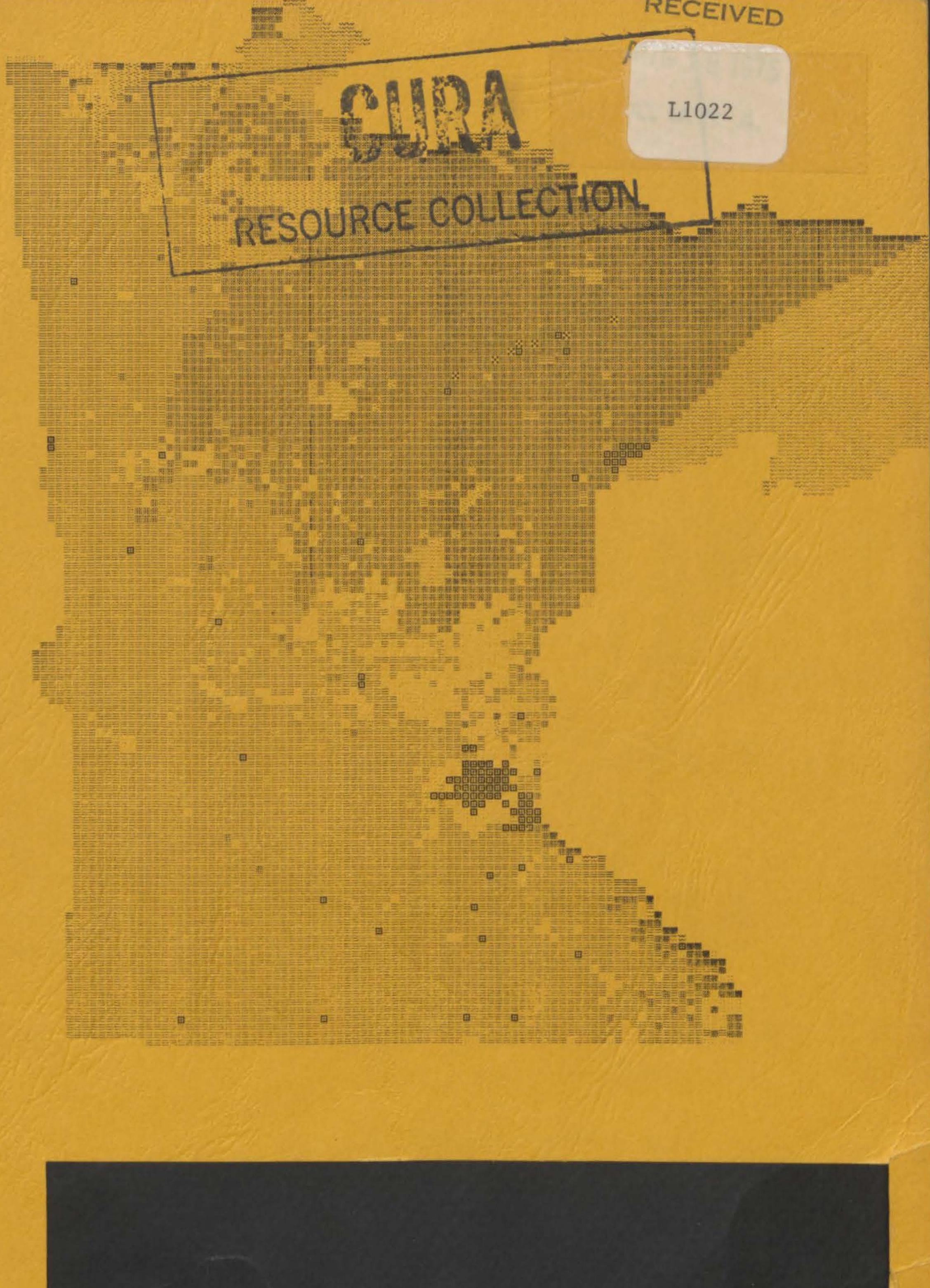
MLMIS



MINNESOTA LAND MANAGEMENT INFORMATION SYSTEM

A Landfill Site Selection Study for Washington County and Ramsey County, Minnesota.
March 1975.

COPY 2

MINNESOTA LAND MANAGEMENT INFORMATION SYSTEM (MLMIS) (CURA)

Dan Urgo
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MINNESOTA LAND MANAGEMENT INFORMATION SYSTEM (MLMIS) (CURA)

UNIVERSITY OF MINNESOTA
CENTER FOR URBAN AND
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A LANDFILL SITE SELECTION STUDY FOR WASHINGTON COUNTY AND RAMSEY COUNTY, MINNESOTA

5015

ALAN ROBINETTE
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Center for Urban & Regional Affairs

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Ramsey County Highway Department

Mr. William Schwab
Washington County Planning Department

Mr. Ray Thron
Metropolitan Council

Dr. Matt Walton, Director
University of Minnesota
Minnesota Geological Survey

Mr. Martin G. Ziebell
District Conservationist
Soil Conservation Service

THE MINNESOTA LAND MANAGEMENT INFORMATION SYSTEM STUDY

The Minnesota Land Management Information System project is an endeavor of the Center for Urban and Regional Affairs (CURA) of the University of Minnesota and the State Planning Agency. Important contributions to the project have been made by other executive and legislative branches of state government, numerous University departments, and other institutions.

The primary goal of this project is to improve the quality of public-private sector land use decisions. The project is doing this by building a data bank containing information on physical resources, relative accessibility to market of these resources, and information on current land use, zoning, and ownership patterns.

Concurrent with the data collection effort is a research program that is using the collected data to simulate land use decisions and conflicts.

TABLE OF CONTENTS

SUMMARY OF ANALYSIS PROCEDURE: WASHINGTON CO. LANDFILL SITE SELECTION

The Problem: Regulations Demand Complex Analysis

The principal criteria to be satisfied in the selection of a site for a landfill operation in Washington County are the mandatory requirements stipulated in the regulations promulgated by the MPCA. These requirements are partly locational and partly site-related in emphasis. For example, MPCA regulations specify setback standards (from airports, highways, lakes, streams, and floodplains) that are inherently locational problems. Therefore, the search for a site satisfying setback standards should systematically locate and identify all of the possible sites or areas that meet this criteria within the region of search. On the other hand, engineering studies investigate the conditions associated with particular sites which have already been located by some conscious or unconscious selection process. MPCA regulations refer to site problems, such as the surficial geology of a site or its vegetation cover and topography. Even these site-related problems have a locational dimension, since sites of inadequate or prohibitive geology, cover or topography may be identified and eliminated through locational analysis well before site-specific engineering analysis takes place, thus avoiding the costs of premature site analysis. It is for these reasons, principally, that the site selection study committee convened by the Metropolitan Council determined that computer locational analysis of Washington County was the best site selection strategy to pursue.

SUMMARY 2

The Approach: Test Every 40-Acre Parcel Against Location Criteria

The information variables necessary to the computer locational search for suitable landfill sites were identified and the variables were organized into 4 discreet steps of analysis (see Appendices 2 & 5 for steps and variables). The first two steps were designed to select out those 40 acre parcels which would be specifically prohibited as landfill sites by the standards in MPCA regulations. The variables organized into step 1 of the analysis identify parcels prohibited for reasons of urban development, shoreline proximity, and unacceptable soils. Step 2 analysis locates parcels prohibited because of their residential character, and proximity to airports, parks, or highways.

Steps 3 and 4 extend locational analysis to environmental factors and to cost and land use factors, respectively. Step 3 variables are intermittent streams, soil with moderate limitations, geology with moderate limitations, vegetation, and planned future development. Step 4 variables are water wells, which should be avoided, and two measures of accessibility, distance from I-694 and proximity to high axle limit roads.

At the end of each step of analysis, a summary map (pp. 18-21 in text following) was produced displaying the prohibited parcels and the remaining "good" sites. Each map, then, shows a step in the process of elimination. A final map (following) shows the location of the 3 best sites in Washington County, that is to say, the sites that have survived the computer locational search.

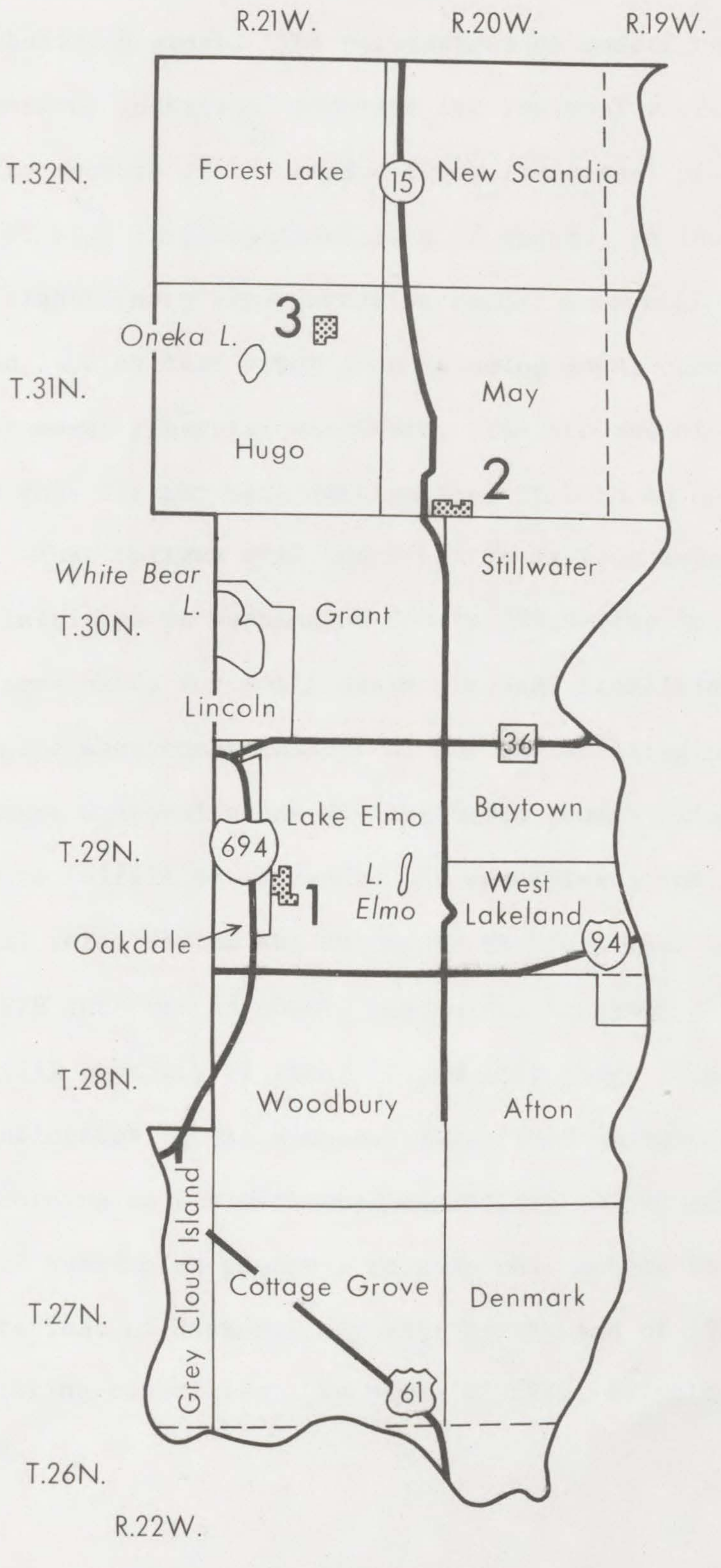
SUMMARY 2A

*[Because of the inadequacy of some information pertaining to environmental health, groundwater hydrology and lack of technical studies related to landfills, particularly in Minnesota, this site selection technique does not make specific recommendation as to the suitability of the three potential sites for a landfill. The study does suggest that for certain parameters selected this offers an excellent procedure for a computerized analysis to select or reject sites for a specific use of land. There are serious questions concerning environmental health, groundwater quality protection, landfill design technology, and economics which could dictate that no area of Washington County is suitable for a landfill. It should be emphasized that this study is to demonstrate the usefulness of a computerized land-use analysis for selecting best use of land from information available. Bad choices, which could produce irreversible damage, can still result when basic data is inadequate or erroneous. There is as yet no demonstrated fail-safe landfill which would positively protect groundwater quality. The site selection techniques did not consider many problems that could be associated with engineering and construction techniques or operation of the landfill if groundwater were to become seriously contaminated in the area.]

* Note: The statement in brackets is a suggested addition to the text written by the Minnesota Department of Health representative of the site selection group.

Figure 1

COMPUTER SELECTED LAND FILL SITES IN WASHINGTON COUNTY



INTRODUCTION

This report describes a land allocation problem of the type increasingly encountered in urbanizing areas. The populations of modern metropolitan centers create enormous locational problems for regional waste disposal. Within the highest density sectors of the region these locational problems are difficult to solve because of high land costs and lack of space. In lower density areas the problems are higher waste transportation costs, potential environmental degradation, and citizen opposition to using local community land as a dumping ground for waste generated elsewhere. The process of siting a solid waste landfill is thus fraught with difficulties of both an environmental and political nature. What follows will describe the salient aspects of a unique siting procedure initiated in Washington County, Minnesota in response to growing metropolitan area needs for solid waste disposal facilities.

The solid waste management chapter of the Metropolitan Development Guide describes solid waste disposal needs for the seven county Twin Cities area and policies designed to fulfill those needs. It specifies a ten year system plan for mixed municipal solid wastes and documents the fact that between the years 1969 and end of 1978 such wastes should accumulate to about 11.5 million tons, requiring a land fill capacity of about 17,100 acre feet. The Council's solid waste plan allocates future disposal capacities among communities in the seven counties according to the estimated capability of respective areas to develop landfills. Washington County's role in this scheme is to provide a total of 2,900 acre feet of disposal capacity by the end of 1978, 2,000 acre feet more than existing capacities. By March of 1975, existing capacities should be exceeded.

Although the Metropolitan Council determines metro region waste disposal needs and suggests the estimated optimum spatial distribution of facilities, it is the Minnesota Pollution Control Agency (MPCA) that is charged with the regulation of solid waste disposal for the whole state. In the language of MPCA regulation SW-5 it is "unlawful to establish, maintain, conduct or operate a solid waste site..." without a permit from the agency. Permits are granted applicants upon the review and approval of a site plan and a plan of operation. This requires the applicant to provide an engineering study of a site as well as to detail waste disposal procedures envisioned for a site. MPCA also passes permit applications through the Metropolitan Council for approval, which is based primarily on the Council's regional needs criteria. Then, if engineering and locational requirements are apparently satisfied, MPCA will grant a permit. If either the Council or the MPCA find fault with the application, it is denied.

In response to the policy of the Metropolitan Council urging outlying metro area communities to develop additional landfill facilities, as well as to the rapidly declining waste disposal capacity in an existing landfill site, Washington County submitted an application for landfill development in Afton Township on June 19, 1973. A site was selected to take advantage of the space and access provided by an abandoned gravel pit. A design was submitted to seal off, collect and treat any leachate generated by the fill. However, information submitted by the Minnesota Geological Survey suggested that if a failure occurred in the retention of leachate it would rapidly contaminate both local and regional groundwater. Consequently, a search for an acceptable site with better natural characteristics for pollution control was proposed.

The Metropolitan Council subsequently appointed an informal landfill site search team to aid Washington County in the designation of a site that would satisfy both MPCA and Council standards. The membership of the search team included representatives from the Metropolitan Council, Washington County Planning Department, Ramsey County, Soil Conservation Service (Washington County branch), Minnesota Pollution Control Agency, Minnesota Geological Survey, Minnesota Department of Health, and the University's Center for Urban and Regional Affairs, which eventually supplied computer facilities and staff time for the site selection process.

As the search team's efforts got underway, a number of clear priorities for the process of site selection emerged. First, the process must determine sites that meet the criteria of MPCA regulations. Second, the process should identify sites and areas meeting reasonable environmental standards not explicitly detailed in any regulations. Third, the process should yield site possibilities entailing the least cost of transportation of waste. And, finally, the process itself should be of such a character that a mountain of data could be manipulated and analyzed objectively and quickly. This last requisite called for a process utilizing a computer.

At the second and subsequent meetings of the search team these priorities were developed into a study procedure for site selection. Broadly, the agency representatives of the committee would supply information from their respective sources and competencies, interpret the information (weight it), code it for computer entry, and give it to the staff of CURA for computer file entry and analysis. At the outcome of computer analysis, search team members would evaluate the best sites remaining after computer runs had identified the incidence of all selection criteria on each 40 acre parcel in the county.

THE STUDY PROCESS

The selection of criteria used to define the site selection process was, in part, accomplished at the outset by the specification of siting constraints found in MPCA regulations (SW-6) governing landfill siting. These regulations comprise a category of mandatory restrictions (Appendix 1). They specify, for example, a series of setback standards prohibiting landfill sites nearer than 1,000 feet from lakes, nearer than 300 feet from streams, and within the 100-year flood mark of flood plains. They also prohibit siting landfills in wetlands, too near airports, within 1,000 feet of occupied dwellings, state, federal, or interstate highways or park boundaries, or in areas unsuitable for reasons of topography, geology, hydrology or soils.

Some of the regulatory criteria thus stated were not directly quantifiable nor sufficiently unambiquous to be entered for computer analysis. Additional definition, in terms to which numbers could be attached, was required. One of the ambiguous criteria in the regulations concerns proximity of sites to airports: the regulation declaring that landfill sites are prohibited in "locations considered hazardous because of the proximity of airports." [Minn. Reg. SW-6(1)] No setback standard is given, a fact which necessitated the establishment of a setback standard by the committee. Another area of ambiguity in the regulations concerned physiography. The regulations prohibit siting landfills in "An area which is unsuitable because of reasons of topography, geology, hydrology, or soils." [Minn. Reg. SW-6(1)] Again, other than prohibiting refuse deposit within five feet of the high water table, the parameters of unsuitability or prohibition are lacking.

The search team defined, for the purpose of this study, the airport proximity prohibition to prohibit any landfill less than one mile from the edges of airport facilities. The prohibitions on siting in areas of unsuitable topography, geology, hydrology, and soils were defined to prohibit, respectively, siting in areas of excessive slope (greater than 13%), areas where bedrock exposure occurs, areas known to be significant to groundwater recharge, areas where the soil type is too permeable, allowing excessive surface infiltration into the refuse and providing little soil attenuation of the leachate, and areas where heavy clay soils would create problems with leachate springs and with site operation. The results of the search team's interpretation and extrapolation of terms in the original regulations, it might be argued, greatly clarify and amplify their intent, and no doubt are an aid to the MPCA in the exercise of their regulatory authority, although no changes in the actual language of the landfill regulation occurred.

In addition to the mandatory criteria imposed by MPCA landfill siting regulations, the search team considered a category of non-mandatory or flexible criteria, also taken from the regulations. This category of flexible environmental criteria would identify sites which, while not to be categorically avoided, still had limitations on suitability for development for landfill. Also, the search team determined the need to include criteria designed to seek lowest transportation cost sites and sites requiring the least expenditure of capital for road construction. Finally, the search team included existing land uses in Washington County as an important criterion.

Contributions from agency members of the search team filled out the criterion categories thus established. The Minnesota Geological Survey contributed a composite map and interpretations of the surficial geology of Washington County, a map of natural and man-made bedrock outcroppings, and records of the locations of private and municipal water wells in the county. The Soil Conservation Service contributed maps, descriptions and interpretations of soil constraints on site selection. Other information including natural land cover, water orientation (land adjacent to water), highway orientation (land adjacent to highways), and land ownership data came from Minnesota Land Management Information Study (MLMIS) and Metropolitan Council files; while existing and proposed Washington County land use was contributed by the Washington County Planning Department.

The information assembled by search team members was grouped into 12 categories: each category constitutes a variable and each variable can be developed into a mapped product using the techniques and hardware supplied by the Center for Urban and Regional Affairs (CURA). Item 2 of the Appendix is a complete list of the variables used in the landfill study. The reader may wish to consult the appendix during the brief discussion of each variable which follows.

VARIABLES

V-01 Vegetation

The data comprising this variable were obtained by CURA staff from a map of land cover/vegetation commissioned by the Metropolitan Council from Wallace, McHarg, Roberts, and Todd, a resources consulting firm. There are 16 classes of vegetation/land cover types, some of which (river bottom, wet meadow, poorly drained meadow and water) quite obviously constitute prohibitions on landfill siting. On the other hand, some of the classes (oak opening barrens and aspen oak complex) might have some environmental limitations on the development of a landfill. Others (grass meadow and farmland) would have only slight limitations on the development of a landfill.

V-02 Surficial Geology

The Minnesota Geological Survey supplied the data used to delineate the surficial geologic units found in Washington County. At the outset of the search team's work, Matt Walton of the M.G.S. had identified two major glacial till surficial units which had the characteristics most desired for a landfill (well graded particle size, low porosity and permeability). The M.G.S. also identified surficial units - glacial drift, alluvial deposits, and glacial lake beds - which have moderate or severe limitations on landfill siting. For the purposes of the landfill study, 9 classes of surficial geological units comprise variable V-02. Table I in Appendix item 3 shows the interpretations given these 9 classes.

V-03 Bedrock Outcrops

Places where bedrock occurs above or near the land surface are undesirable for landfill sites because they lack cover material for refuse burial and an adequate substrate to absorb solid waste leachate. Also, some bedrock outcrops are points of aquifer recharge, which means that the leachates of material deposited on bedrock aquifer can find their way into groundwater sources. The 4 classes of this variable identify man-made, natural or combinations of man-made/natural outcrops.

V-04 Water Orientation

CURA supplied this variable from the tape files of the Minnesota Land Management Information System. The term orientation implies that only land parcels touching a water body are referenced. All data on MLMIS files is coded for 40 acre parcels. Hence, any 40 acre parcel, part of which is directly adjacent to water, is water oriented. The existence of water very near a possible landfill site would generally amount to a prohibition against development there. The classes of this variable catalogue the type of water adjacent to the parcel.

V-05 Slope

The search team determined that, for the purposes of this study, terrain with slopes of over 13 percent is inappropriate for landfill use in Washington County to avoid potential seepage from a landfill at the bottom of the slope. Extreme slopes can also cause operational difficulties. The first three classes of this variable (encompassing slopes of from 0 to 13 percent) are acceptable slope conditions for landfill siting; classes 5-6 (over 18%) are not.

V-06 Soil

There are 58 classes of soil represented on the S.C.S. soil series map for this variable. Broadly, the criteria for proper landfill soil types include a texture ranging from sandy loam to sandy clay loam, permeability (or percolation rate) less than 2.0 inches per hour, drainage good to excessive, and slope (as above) less than 13 percent. The limitations for landfill development for each of the 58 soil classes for V-06 are found in Appendix 4.

V-07 Land Use Restrictions

Washington County Planning Department gathered information on existing and potential development within the county. This information was grouped into six classes. Two classes, semi-developed and developed, constitute an outright prohibition against landfill siting. Class 3, near airport, is also a prohibition if the siting near an airport is a hazard, in the terms of MPCA regulations. Class 0, open land, as well as class 1, near park, and class 4, anticipated development, are all possible areas for search, (class 1, especially so since reclaimed landfill might be used to extend existing park land).

V-08 Highway Orientation

The term orientation in this context connotes the same definition as variable V-04, water orientation. MLMIS tape files contain a record of 40 acre parcels which touch or contain roads. The 24 classes of the variable describe either intersection types or simple road types. The significance of the variable is its ability to identify parcels of land too near state, federal and interstate highways, according to MPCA setback requirements.

V-09 Water Wells

Under the best of conditions of surficial geology and soil type leaching from landfill material into groundwater supplies is always a possibility. Accordingly, the M.G.S. used their records of water well locations in Washington County to produce V-09. All of the classes, except 0, comprise places where a landfill site would represent a hazard to well water sources.

V-15 Axle Weights

The Metropolitan Council recommends a 9 ton axle limit as the minimum standard for roads used for hauling solid waste to a disposal site, but would accept 7 tons. The 5 classes of V-15 make it possible to identify 40 acre parcels by axle limit road type. Data came from Washington County Highway Department.

V-16 Haul Distance

Accessibility of a site to Interstate 694 was deemed by search team members to be an important variable, since the source of landfill material in Ramsey County is most directly reached *via* I-694. Classes of the variable identify the distance a site is from the interstate road, although class 1 identifies parcels right on the freeway and class 0 identifies parcels farther away than 3 miles from I-694.

V-32 Near Axle Limit Roads

This variable is related to V-15, above. While V-15 identifies 40 acre parcels with specified axle limit roads within them, V-32 encompasses 40 acre parcels with 9 or 7 ton limit roads plus parcels at distances of 1/4 mile, 1/2 mile, and 1 mile from a 9 ton axle limit road.

CODING

An important procedure preceding map production and analysis is the transformation of the assembled mapped or tabular information into numbered cells necessary for computer entry. This process is called coding. For example, the soils maps supplied by the S.C.S. were coded by overlaying an acetate grid with a honey comb of cells, each bounding 40 acres on the soil map (Figure 1). The soil types are each previously assigned a number which is entered in the respective acetate cell superimposed on that soil type. When all the cells have been coded for a complete township, the process is repeated until all townships in the county are coded. The coded information is punched on computer cards and is ready for entry into computer files from which maps may be produced showing the distribution, in the case of the example above, of various soil types in Washington County.

ANALYSIS

The study design that is the core of analysis for the site selection process has three components: 1) organization of the 12 site selection variables into 4 analysis steps or stages such that the first stage contains the most restrictive limitations on siting while the last stage contains the least; 2) production of 12 variable-display maps each showing the distribution of prohibited and suitable aggregates of 40 acre parcels and 3) production of 4 composite maps, each of which sums up the analysis steps for each respective stage such that at the end of each stage computer run, a group of "good sites" clears analysis of that stage and wins the right to be put in the hopper of the next.

The organization of the 12 variables listed in Appendix 2 was guided by the need to, minimally, satisfy the MPCA regulations governing landfill site suitability, and secondarily to seek out the least environmentally pernicious and least cost site (s). MPCA regulations contain, as we noted, a set of absolute setback requirements and a set of flexible requirements, the latter to which the study committee, for purposes of analysis, assigned absolute values. Stage 1 analysis covered the mandatory category and stage 2, the flexible.

Stage 1 thus became an analysis process devoted to locating those aggregates of parcels that presented an inflexible prohibition against landfill siting. In this category were placed those variables which identified such prohibitions as existing urban development, parcels near water, unacceptable surficial geology, wetland parcels, steep slopes, and unacceptable soils (see Appendix 5).

Stage 2 contained those variables which constituted a flexible prohibition on parcels identified. It included prohibitions associated with low density urban development, sites nearer than 1 mile from airport facilities, and parcels distant from highways. The summation of flexibly and inflexibly prohibited aggregates of parcels yielded those sites which MPCA regulations would specifically prohibit. The balance of analysis dealt with environmental and cost factors.

Stage 3, environmental variables, ranked the remaining viable parcels after stages 1 and 2 according to limitations imposed by moderately unsuitable soils, geology, and vegetation, as well as by anticipated urban development. The parcels graduated from stage 3 went on to stage 4 analysis to be subjected to the criteria of cost and ancillary land use factors such as proximity of sites to water wells, haul distance from interstate 694, and accessibility of parcels to high axle limit roads.

The product of each stage was a composite map. On the following pages the map summaries of each analysis stage are shown. Note the way in which aggregates of parcels that are good sites (light shaded areas of maps) visually standout from the prohibited, (darkly shaded) sites. A few examples of the display maps which, when aggregated, from the composite maps, are shown in Appendix 6.

When analysis was completed, 3 sites (Figure 1) satisfied the 4-step analysis plus the space requirement of five or more contiguous 40 acre parcels. Site number one (Figure 1), the computer selected best site, is located in Lake Elmo Township, section 20. The second priority site, number two, is located in May Township, sections 32 and small part 33; and site three in Oneka Township, section 10,11 and small part 2. Filtered through the criterial screen of what would have been a nearly impossible task by more conventional means, the computer selected sites represent the finely tuned product of a complex search.

*[It should be recognized that unless the landfill site can be adequately sealed and contained, the leachate from the landfill will seep through the soil and reach the groundwater. It is likely that this leachate material will, in time, eventually enter surrounding private and municipal water supply systems with undetermined, but potentially deleterious effects. The fact that hazardous materials may be present even in small concentrations in landfills cannot be ignored for the obvious reason of the quantity of material involved. In the disposal of solid waste, not only are inorganic trace elements and water leachable salts and methane gas to be considered, but also items which may have proven carcinogenic or mutagenic effects.

To relate the health factors to the other parameters of the study and thus produce a truly comprehensive evaluation of the site, would require a more adequate multidiscipline approach. Any environmental health approach should include the short and long term effects of contaminate materials as well as an appropriate study of the health problems from sanitary landfill activity.

Considering the potential threat to groundwater quality associated with the availability and use of the water resources in the area, there are serious questions related to the acceptability of the sites for use as sanitary landfills in accordance with presently used technology for design, construction, maintenance and operation.

Once major groundwater contamination has taken place, the efforts and remedies needed to rectify such conditions can become intractably difficult. There are reports which have shown the dangerous consequences of leachate contamination to the groundwater and its damaging effect to the surrounding communities.

Although an attempt to evaluate the environmental health impact of landfill activity may be complex and difficult, it would seem in the interests of the public health and safety that it be included in a landfill site selection study.

There are a number of questions that would have to be resolved prior to making a decision on whether or not there are any available locations in Washington County which would be usitable for a landfill. For example, the hydrologic data of the area should be studied to determine if there is sufficient data available to make an analysis of the impact on groundwater quality. The soil data was used without taking into consideration the following SCS guideline:

> "The size and character of landfills are such that it is not practical to remove refuse if a pollution problem should arise. Consequently, thorough evaluation of site hydrology is essential beforehand."

According to a report prepared by G. M. Hughes, R. A. Landon, and R. N. Farvolden, the Illinois State Geological Survey, Urbana, Illinois, under a Demonstration Grant from the Federal Solid Waste Management Program:

> "As refuse leachate migrates through the ground is is attenuated by ion exchange, dilution, dispersion, complexing, and filtration. Fine-textured materials have a high capacity for retaining the dissolved solids in refuse leachate and, owing to their low permeability, permit only a low rate of groundwater movement. Sands and gravels have less capacity to retain the dissolved solids, and high rates of movement are possible. Fractured rocks retain relatively small amounts of the dissolved solids, and extremely high rates of groundwater movement are possible.
>
> The amount of ion exchange a particular ion undergoes depends on several factors, including the following: (1) the type of material involved; (2) the ions already present on the surface of the clays; (3) the other elements in solution and their concentration.
>
> Laboratory experiments to determine how much exchange will take place as a solution is passed through a given material may yield useful results, although extrapolation to field conditions requires care

(McHenry et al., in de Laguna, 1955, p. 190). In such experiments most of the soil is in contact with the solution, but under field conditions, in which permeability varies because of minor sand bands or fractures, this may not be the case.

Less dilution and dispersion of contaminants will take place in groundwater than in surface waters because groundwater flow is almost always laminar, whereas flow of surface water is generally turbulent. For this reason, the total volume in a groundwater reservoir cannot be considered effective for diminishing the concentration of contaminants. McKee and Wolf (1963, p. 20) also pointed out that the low travel velocities and diffusion rates in groundwater reservoirs can produce serious consequences when contamination occurs. Contamination may not be noticed for years or decades, and consequently no complaints are registered. Even after contamination is discovered, the quality of water is already degraded and the damage cannot be repaired merely by stopping the source of contamination. A longer time may be required to purify groundwater than to contaminate it."

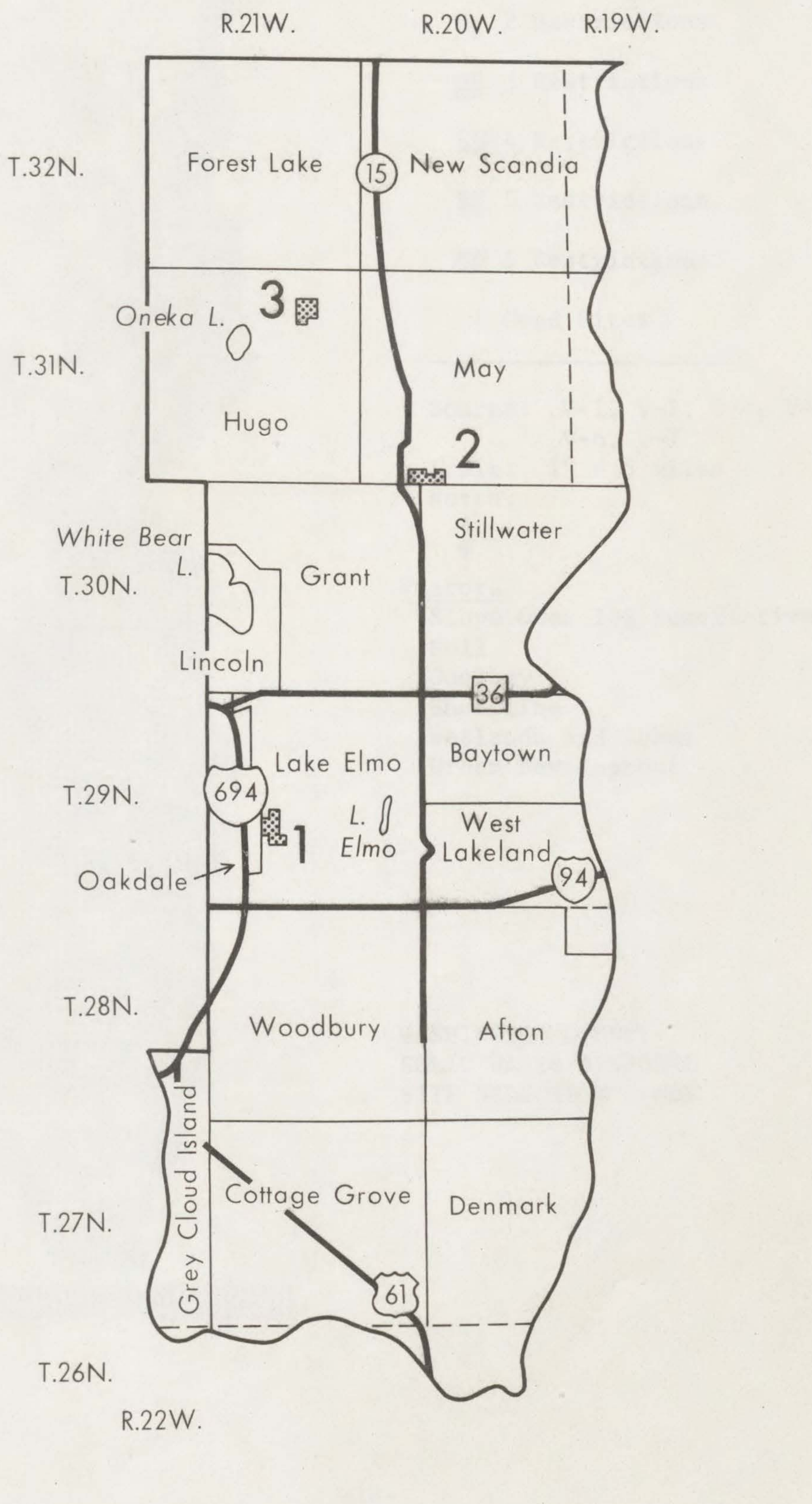
Some other aspects that have not been determined with respect to the use of landfills in an area relate to the enforcement and monitoring of materials entering a landfill where serious contamination can result to important ground aquifers of the area. Since trucks hauling refuse to a landfill contain anything discarded from human activity it is nearly impossible to provide the manpower that it would take to realistically evaluate the material entering the landfill and to turn away unsuitable, hazardous, toxic, carcinogenic or mutagenic materials. Other needed administrative, legal and funding procedures have not been addressed adequately by public policy bodies.

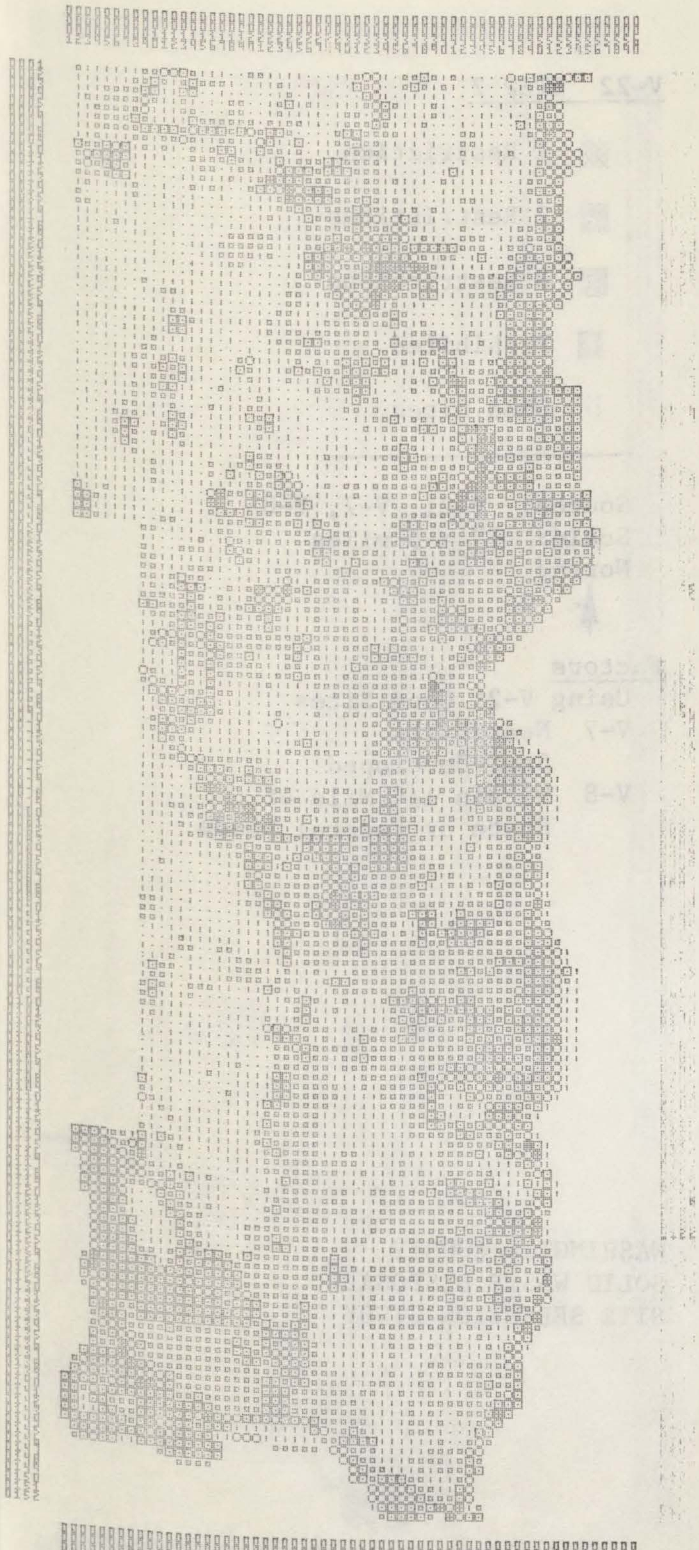
If groundwater should be contaminated by a landfill, no alternative water supply has been suggested for the area.]

* Note: The statement in brackets is a suggested addition to the text written by the Minnesota Department of Health representative of the site selection group.

Figure 1

COMPUTER SELECTED LAND FILL SITES IN WASHINGTON COUNTY





V-21 STEP 1

1 Restriction

2 Restrictions

3 Restrictions

4 Restrictions

5 Restrictions

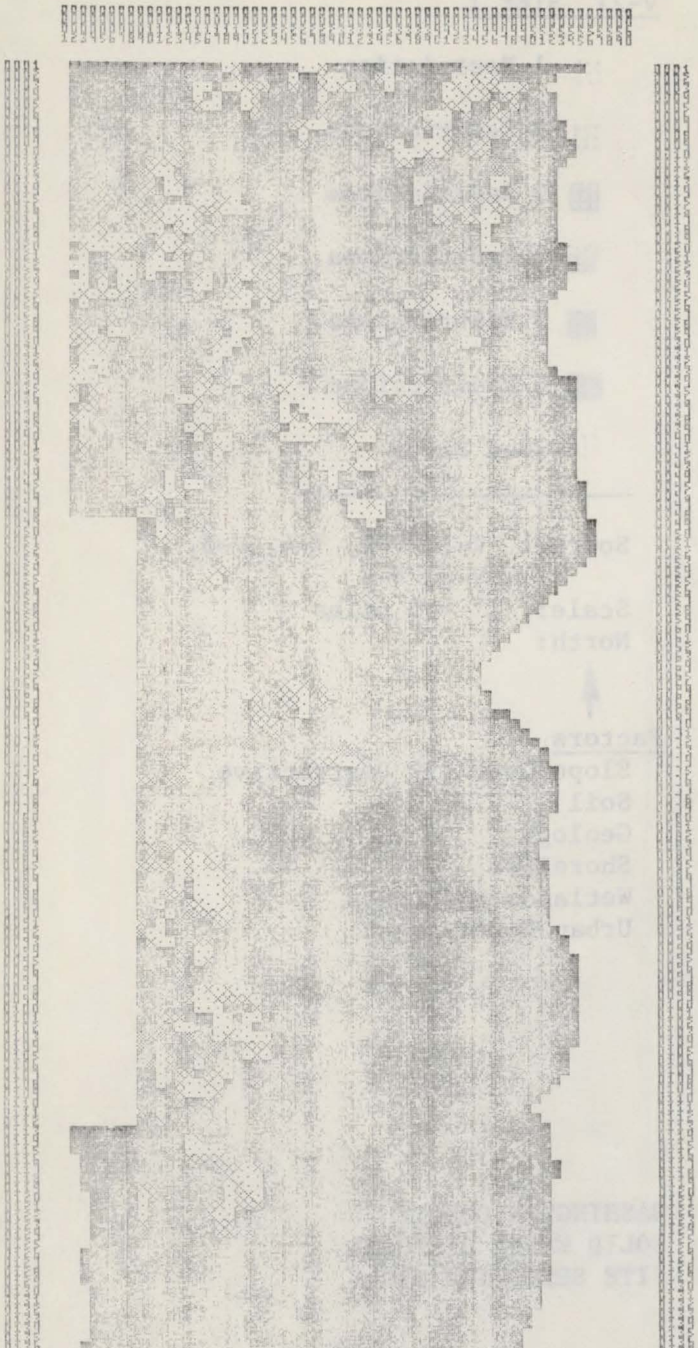
6 Restrictions

Good Sites

Source: V-1, V-2, V-4, V-5, V-6, V-7
Scale: 1" = 5 miles
North:

Factors
- Slope Over 13% Restrictive
- Soil
- Geology
- Shoreline
- Wetlands and Lakes
- Urban Development

WASHINGTON COUNTY
SOLID WASTE DISPOSAL
SITE SELECTION STUDY



V-22 STEP 2

1 Restriction

2 Restrictions

3 Restrictions

Prohibited

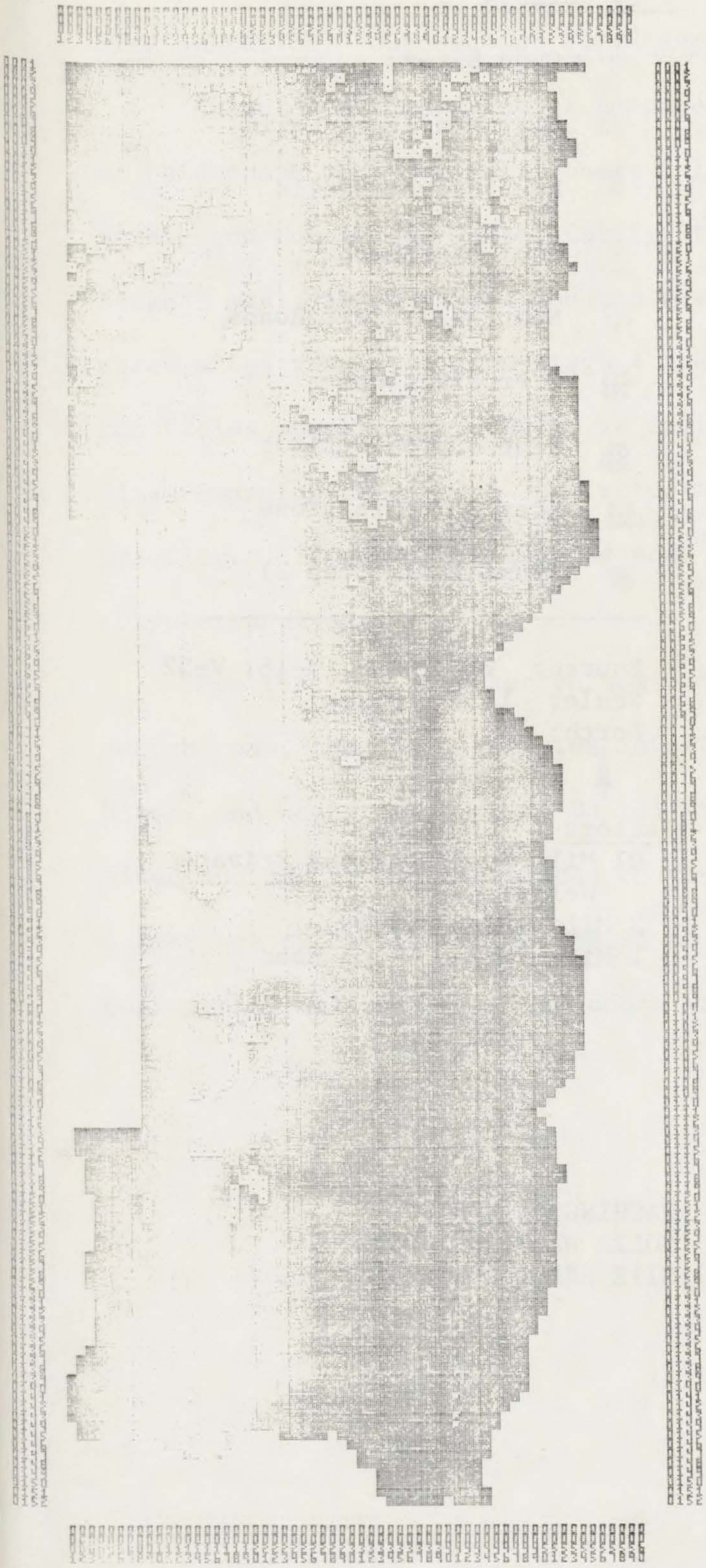
Good Sites

Source: V-21, V-7, V-8
Scale: 1" = 5 miles
North:

Factors

Using V-21 Good Sites
V-7 Near Parks
Semi-Developed
V-8 Within 1/4 Mile of
State or Federal Roads

WASHINGTON COUNTY
SOLID WASTE DISPOSAL
SITE SELECTION STUDY



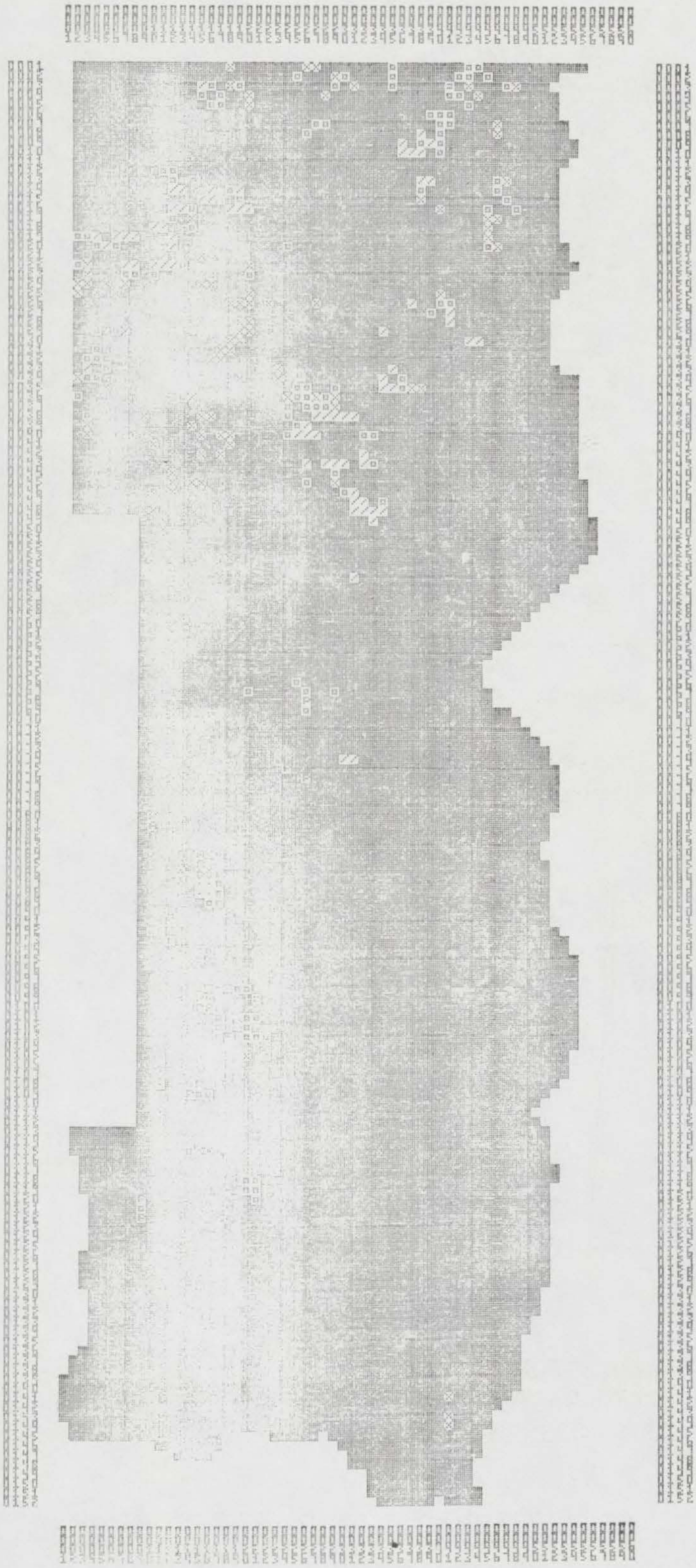
V-23 STEP 3

- Good Sites
- Geology
- Vegetation
- Intermittent Streams
- Future Development
- 2 Restrictions
- 3 Restrictions
- Prohibited

Source: V-22, V-1, V-2, V-4
V-7
Scale: 1" = 5 miles
North:

Factors
Moderate Geology
Moderate Soils
Intermittent Streams
Future Development

WASHINGTON COUNTY
SOLID WASTE DISPOSAL
SITE SELECTION STUDY



V-24 STEP 4

- Good Sites
- Near Municipal Wells
- Near Private Wells
- Haul Distance
- Near Axle Limit Roads
- 2 Prohibitions
- 3 or 4 Prohibitions
- Step 3 Prohibitions
- Prohibited (Step 2)

Source: V-23, V-9, V-16, V-32
Scale: 1" = 5 miles
North:

Factors
01 Mile Municipal and Private Wells
3 Miles From 694-494
1 Mile From a 9-Ton Road

WASHINGTON COUNTY
SOLID WASTE DISPOSAL
SITE SELECTION STUDY

SITE SELECTION: Outcomes of Field Reconnaissance

Actual field checking of computer selected sites was the last component of this phase of the landfill site selection. In early September, 1974, Washington County and Ramsey County Staff field checked ten sites drawn from stage 3 analysis (this was done to give a wider field survey sample than the three sites resulting from stage 4 analysis permitted). Five sites in the ten fields checked appeared to be suitable for further consideration. The five remaining sites were then rated and the best three given highest priority. Sites 1 and 2 are the same ones given the highest priority by the computer analysis.

Now that the site search has been narrowed to three sites by the search team, the three agencies involved (Metropolitan Council, Ramsey County Board, and Washington County Board) will have to jointly review the recommended sites and the priorities placed on them. As soon as these agencies concur on a number one priority site, phase II of the site selection process (specific site engineering analysis) can get under way.

RETROSPECTIVE

The Washington County landfill site selection case, even though it has not yet culminated in site approval by the regulating agencies, presents us with some insights which might have currency at other times and for other types of land allocation conflict.

Evaluate Location First, Site Second

It has been demonstrated in a practical manner that a computer land data system is useful, if not indispensible, to complex locational problems. This is so for the obvious reason of low data handling and analysis costs and for the concommitant reason of the capability of computers to manipulate ordinarily overwhelming amounts of information. It is equally so because computers are inherently objective in analysis, leaving the subjective tasks of weighting and interpreting information to human managers of computers. But the computer is an important tool, above all, because of its unique applicability to locational, in contradistinction to site, analysis.

Traditionally, as we have seen, landfill site permit applications are accompanied by engineering reports detailing the suitability of a site somewhat arbitrarily selected from available open space areas. Although the engineering plans may be the best possible for the stipulated site, the site itself might not be the best possible site of those actually available. Only locational analysis (and by this is meant the systematic screening of each possible site within a specified region using a set of detailed and comprehensive criteria) followed by site analysis can produce the best result. Of course, the spatial analytical capabilities of computer land data systems extend to many problems other than landfill siting. Such systems may be used to identify the suitability of land for an infinite number of uses, once criteria and information sources are determined. It is possible to assess, for example, the highest suitabilities of land in a region for residential, agricultural, industrial/commercial, and recreational uses. This is the case because every type of land use has its own inherent environmental requirements: residential uses require adequate soil strength for construction, agricultural uses require productive soil, and so on. Factors of this type, in combination with cost factors and the factors of political decisions, can be used to screen parcels of land to find the most suitable parcels for any particular use.

Value of Team Approach

A second insight from this case is that many sources of information are better than a few. A corollary is that the judgments of many individuals, when sifted through the screen of discussion and analysis, is better than a few. The team approach to the landfill site selection process, as it was represented by the search team, developed a broader field of information, considered more points of view, and produced a more reliable set of findings than could ever have been expected from one agency. It also, very simply, promoted communication between the regulating, advising, and implementing agencies.

Examine Geographic Impact Of Policies

A final insight is the proof that regulations established by public policy can be computer simulated. This is not generally a new proof, but the simulation (mapping) of MPCA regulations governing solid waste disposal sites (a public policy) in the Washington County case is the first occasion of its type in Minnesota. Imagine the possible applications of the ability to map the impacts of policy decisions on the environment before the decisions and the impacts become irrevocable. A few applications spring to mind: to agricultural policies, recreation policies, metropolitan growth policies, to transportation, and copper-nickel policies, and so on. The list in Minnesota is quite limitless. It is instructive to note, too, that when public policy, in this case waste disposal regulations, is subjected to computer simulation, the policy itself comes under intense scrutiny. The outcome of scrutiny in the present case was a tighter specification of terms and setback criteria in the MPCA regulations. Perhaps the MPCA will see fit to permanently improve their regulation (SW-6) governing sanitary landfills by including the quantified definitions developed by the search team.

APPENDIX 1

EXCERPTS FROM MINNESOTA REGULATION
SW 6 SANITARY LANDFILL

SW 6 Sanitary Landfill

The sanitary landfill method shall be used for all final disposal of solid waste.

(1) The fill and trench areas of sanitary landfill sites are prohibited within the following areas, as existing at the time of receipt of the permit application by the Agency:

(a) 1,000 feet from the normal high water mark of a lake, pond or flowage.

(b) 300 feet from a stream.

(c) A regional flood plain (100 year flood).

(d) Wetlands.

(e) Within 1,000 feet of the nearest edge of the right-of-way of any state, federal or interstate highway or of the boundary of a public park or of an occupied dwelling. Permission may be granted under this subsection, without these distance requirements, at the discretion of the Director, taking into consideration such factors as noise, dust, litter and other aesthetic and environmental considerations.

(f) Locations considered hazardous because of the proximity of airports.

(g) An area which is unsuitable because of reasons of topography, geology, hydrology, or soils...

(2b) Solid waste shall not be deposited in such a manner that material or leachings therefrom may cause pollution of underground or surface water.

Proposed separation between the lowest portion of the landfill and the high water table elevation shall be a minimum of five feet. This requirement shall not be construed to render inoperative any other requirements specified herein and additional groundwater protection shall be provided if needed...

(2h) The approach road to the disposal site and the access road on the site shall be of all-weather construction and maintained in good condition so that they will be passable at all times for any vehicle using the site...

(2s) A water monitoring program shall be constructed and operated to determine whether or not solid waste or leachate therefrom is causing pollution of underground or surface water. The drilling and construction of all site wells, including those used for monitoring purposes, shall be done in compliance with Minnesota Statutes 1973, Chapter 747.

The conditions of monitoring, including the frequency and the analysis of water monitoring samples, shall be determined by the Director and may be changed at his discretion.

APPENDIX 2

RESOURCE INVENTORY LISTING

WASHINGTON COUNTY SOLID WASTE DISPOSAL SITE SELECTION STUDY

Map No.	Name	Class No.	Class Name	Description
V-01	VEGETATION	1	BIG WOODS	
		2	RIVER BOT.	RIVER BOTTOM
		3	FARMLAND	
		4	GRASS MEAD	GRASS MEADOW
		5	WET MEADOW	
		6	URBAN GEN.	URBAN GENERAL
		7	URBAN TREE	URBAN WITH TREES
		8	PLANTATION	CONIFEROUS PLANTATION
		9	POOR DRAIN	POORLY DRAINED MEADOW
		10	MARSH	SHALLOW AND DEEP MARSH
		11	MUDFLATS	MUDFLATS AND SANDY SHORES (NONE)
		12	ASPEN BIRCH	ASPEN BIRCH
		13	WOOD SWAMP	WOODED SWAMP
		14	OAK OPEN.	OAK OPENING BARRENS
		15	ASPEN-OAK	ASPEN OAK COMPLEX
		16	WATER	
V-02	SURFICIAL GEOLOGY			
		1	ALLUVIUM	
		2	D. TILL	DES MOINES LOBE TILL
		3	D. OUTWASH	DES MOINES LOBE OUTWASH SAND AND GRAVEL
		4	D. VALLEY	DES MOINES LOBE VALLEY-TRAIN SAND AND GRAVEL
		5	D. LAKE	DES MOINES LOBE LAKE DEPOSIT
		6	S. TILL	SUPERIOR LOBE TILL
		7	S. OUTWASH	SUPERIOR LOBE OUTWASH SAND AND GRAVEL
		8	GLAC. DRIFT	GLACIAL DRIFT, UNDIFFERENTIATED
		9	BEDROCK	SHALLOW DEPTHS TO BEDROCK
V-03	BEDROCK OUTCROPS			
		0	NONE	
		1	NATURAL	NATURAL OUTCROP
		2	MAN-MADE	MAN-MADE BEDROCK EXPOSURE
		3	BOTH	COMBINATION OF BOTH OF THE ABOVE
V-04	WATER ORIENTATION			
		0	NO WATER	
		1	ISLAND	
		2	MEAND. LAKE	SURVEYED LOTS

Map No.	Name	Class No.	Class Name	Description
		4	PUBLIC LAKE	NON-SURVEYED LOTS
		7	MEAN. RIVER	SURVEYED LOTS
		8	PUBL. RIVER	NON-MEANDERED RIVER FLOWS YEAR ROUND
		9	DITCH-DRY	DRAINAGE DITCH OR NON-MEANDERED, SEASONALLY DRY RIVER
V-05	SLOPE			
		1	0 - 3 PCT.	
		2	3 - 8 PCT.	
		3	8 -13 PCT.	
		4	13 -18 PCT.	
		5	18 -30 PCT.	
		6	30 + PCT.	
V-06	SOIL			
		1	CARRING SL	CARRINGTON SILT LOAM
		2	LINDSTROM	LINDSTROM LOAM
		3	FREER SILO	FREER SILT LOAM
		4	ADOLPH SCL	ADOLPH SILTY CLAY LOAM
		5	BLUFFTON S	BLUFFTON SILTY CLAY LOAM
		6	ONEKA FISL	ONEKA FINE SANDY LOAM
		7	HAYDEN FSL	HAYDEN FINE SANDY LOAM
		8	HINES SILO	HINES SILT LOAM
		9	MILACA SIL	MILACA SILT LOAM
		10	SANTIAGO	SANTIAGO SILT LOAM
		11	CARRIN FSL	CARRINGTON FINE SANDY LOAM
		12	ETTER SILO	ETTER SILT LOAM
		13	ROCKTON SL	ROCKTON SILT LOAM
		14	DUBUQUE SL	DUBUQUE SILT LOAM
		15	GALE SILO	GALE SILT LOAM
		16	BOONE LOFS	BOONE LOAMY FINE SAND
		17	ONEK-MILAC	ONEKA-MILAKA COMPLEX
		18	KINGHURST	KINGHURST LOAMY FINE SAND
		19	KROESCHEL	KROESCHEL LOAMY FINE SAND
		20	MILACA FSL	MILACA FINE SANDY LOAM
		21	SCANDIA LS	SCANDIA LOAMY FINE SAND
		22	WARMAN LOS	WARMAN LOAMY SAND
		23	WITHROW UN	WITHROW SOILS, UNDIFFERENTIATED
		24	WITHROW SL	WITHROW SILT LOAM
		25	WAUKESHA SL	WAUKESHA SILT LOAM
		26	BRICKTON S	BRICKTON SILT LOAM
		27	KNIFE LAKE	KNIFE LAKE SILT LOAM
		28	LANGDON SL	LANGDON SILT LOAM
		29	LANDO SLS	LANGDON SILT LOAM, SHALLOW PHASE
		30	WAUKEGAN S	WAUKEGAN SILT LOAM
		31	GREEN B SL	GREENBUSH SILT LOAM
		32	BAYPORT LO	BAYPORT LOAM
		33	BAYPORT SL	BAYPORT SANDY LOAM

Map No.	Name	Class No.	Class Name	Description
V-06				
	SOIL	34	BURKHARDT	BURKHARDT SANDY LOAM
		35	COPAS FISL	COPAS FINE SANDY LOAM
		36	COPAS LOFS	COPAS LOAMY FINE SAND
		37	GREENB FSL	GREENBUSH FINE SANDY LOAM
		38	HUBBARD FS	HUBBARD FINE SANDY LOAM
		39	LACROSSE L	LACROSSE LOAM
		40	ONEIL SALO	O'NEILL SANDY LOAM
		41	SPARTA FIS	SPARTA FINE SAND
		42	EDITH GRSL	EDITH GRAVELLY SANDY LOAM
		43	EDITH SAND	EDITH SAND
		44	BERRIEN LF	BERRIEN LOAMY FINE SAND
		45	ONAMIA FSL	ONAMIA FINE SANDY LOAM
		46	ONAMIA LOS	ONAMIA LOAMY SAND
		47	ZIMMER LFS	ZIMMERMAN LOAMY FINE SAND
		48	ISANTI FSL	ISANTI FINE SANDY LOAM
		49	ISANTI LFS	ISANTI LOAMY FINE SAND
		50	JUDSON SIL	JUDSON SILT LOAM
		51	WABASH SIL	WABASH SILT LOAM
		52	MUCK	
		53	PEAT	
		54	ALLUVIAL	ALLUVIAL SOIL
		55	BEACH SAND	BEACH SAND
		56	COPAS LOFS	COPAS LOAMY FINE SAND
		57	RIVERWASH	
		58	ROUGH LAND	ROUGH BROKEN LAND
		59		
		60	WATER	
V-07	LAND USE RESTRICTIONS			
		0	OPEN LAND	
		1	NEAR PARK	WITHIN 1/4 MILE
		2	PARK	
		3	AIRPORT	NEAR AIRPORT
		4	FUTURE	ANTICIPATED DEVELOPMENT
		5	SEMI-D.	SEMI-DEVELOPED
		6	DEVELOPED	
V-08	HIGHWAY ORIENTATION			
		0	OPEN LAND	
		1	COAC/COAC	INTERSECTION OF 2 CONTROLLED ACCESS ROADS
		2	COAC/FOUR	INTERSECTION OF A CONTROLLED ACCESS AND A NE ROAD
		3	FOUR/FOUR	INTERSECTION OF 2 4 LANE ROADS
		4	COAC/STAT	INTERSECTION OF A CONTROLLED ACCESS AND A STATE OR FEDERAL ROAD

Map No.	Name	Class No.	Class Name	Description
V-08	HIGHWAY ORIENTATION			
		5	FOUR/STAT	INTERSECTION OF A 4 LANE AND STATE OR FEDERAL ROAD
		6	STAT/STAT	INTERSECTION OF 2 STATE OR FEDERAL ROADS
		7	COAC/COUN	INTERSECTION OF A CONTROLLED ACCESS AND A COUNTY ROAD
		8	FOUR/COUN	INTERSECTION OF A 4 LANE AND A COUNTY ROAD
		10	STAT/COUN	INTERSECTION OF A STATE OR FEDERAL AND A COUNTY ROAD
		11	COUN/COUN	INTERSECTION OF 2 COUNTY ROADS
		12	COAC/NOPA	INTERSECTION OF A CONTROLLED ACCESS & AN UNPAVED ROAD
		13	FOUR/NOPA	INTERSECTION OF A FOUR LANE & UNPAVED ROADS
		14	STAT/NOPA	INTERSECTION OF A STATE OR FEDERAL & UNPAVED ROAD
		15	UNPAVED	
		16	COUN/NOPA	INTERSECTION OF A COUNTY & UNPAVED ROAD
		17	NOPA/NOPA	INTERSECTION OF 2 UNPAVED ROADS
		18	CON ACCESS	4 LANE CONTROLLED ACCESS
		19	FOUR OTHER	4 LANE OTHER
		20	STA-FED	2 LANE PAVED STATE OR FEDERAL
		21	COUN PAVED	2 LANE COUNTY. PAVED
		24	RESIDENT.	RESIDENTIAL
V-09	WATER WELLS			
		0	NONE	
		1	MUNICIPAL	
		2	PRIVATE	
		3	SEVERAL PR	TWO OR MORE PRIVATE WELLS IN A 40 ACRE PARCEL
		4	NEAR MUNI.	WITHIN 1 MILE OF A MUNICIPAL
		5	NEAR PRIV.	WITHIN 1 MILE OF A PRIVATE WELL
		6	NEAR SEV.	WITHIN 1 MILE OF A 40 ACRE PARCEL WITH 2 OR MORE WELLS
V-15	AXLE WEIGHTS			
		0	OPEN	
		1	9 TON/AXLE	LIMIT
		2	7 TON/AXLE	LIMIT
		3	6 TON/AXLE	LIMIT
		4	5 TON/AXLE	LIMIT
V-16	HAUL DISTANCE			
		0	OPEN	
		1	694	
		2	1 MILE	1 MILE FROM 694

Map No.	Name	Class No.	Class Name	Description
V-16	HAUL DISTANCE			
		3	2 MILES	2 MILES FROM 694
		4	3 MILES	3 MILES FROM 694
V-32	NEAR AXLE LIMIT ROADS			
		0	FAR	
		1	9 TON LIMIT	9 TON AXLE LIMIT ROAD
		2	7 TON LIMIT	7 TON AXLE LIMIT ROAD
		3	1/4 M.-9 TON	1/4 MILE FROM A 9 TON ROAD
		4	1/2 M.-9 TON	1/2 MILE FROM A 9 TON ROAD
		5	1 M.-9 TON	1 MILE FROM A 9 TON ROAD
		6	1/4 M.-7 TON	1/4 MILE FROM A 7 TON ROAD
		7	1/2 M.-7 TON	1/2 MILE FROM A 7 TON ROAD
		8	1 M.-7 TON	1 MILE FROM A 7 TON ROAD
		9	PROHIBITED	STATE OR FEDERAL ROADS
ANALYSIS ----------				
V-21	STEP 1	1	URBAN	URBAN RESTRICTIONS
		2	SHORE	SHORELAND RESTRICTIONS
		4	GEOLOGY	GEOLOGICAL RESTRICTIONS
		8	WETLAND	WETLAND RESTRICTIONS
		16	SLOPE	SLOPE RESTRICTIONS
		31	GOOD SITES	NO RESTRICTIONS
		32	SOIL	SOIL RESTRICTIONS
			OTHERS	COMBINATIONS OF 1-16 AND 32.
V-22	STEP 2	1	SEMI-URB	1-4 HOUSES IN 40 ACRES
		2	NEAR AIR	1 MILE FROM AN AIRPORT
		4	NEAR PRK	1/4 MILE FROM A PARK
		8	HIGHWAYS	STATE-FEDERAL- 4 LANE
		5,12	COMBINATIONS	
		32	PROHIBITED	RESTRICTED FROM STEP 1
		33	GOOD SITES	
V-22b		34	GOOD/SLOPE	GOOD SITES EXCEPT FOR SLOPE RESTRICTIONS
V-23	STEP 3	1	SOIL	MODERATE SOIL RESTRICTIONS
		2	GEOLOGY	MODERATE GEOLOGICAL RESTRICTIONS
		4	VEG.	DESIRABLE VEGETATION
		8	DITCH	SEASONALLY DRY STREAMS
		16	FUTURE	SITES OF PLANNED DEVELOPMENT
		32	PROHIBITED	PROHIBITED IN STEPS 1 AND 2
		33	GOOD SITES	
V-24	STEP 4	1	MUN. WELL	WITHIN 1 MILE OF A MUNICIPAL WELL
		2	PRI. WELL	WITHIN 1 MILE OF A PRIVATE WELL
		4	DISTANCE	WITHIN 3 MILES OF 694
		8	WEIGHT	WITHIN 1 MILE OF A 9 TON ROAD
		16	STEP 3	STEP 3 PROHIBITIONS
		32	PROHIBITED	PROHIBITED IN STEPS 1 AND 2
		33	GOOD SITES	

APPENDIX 3

TABLE I

	Surficial Geological Unit	Limitations for Sanitary Landfill Site	Grid Symbol
1.	Floodplain alluvium	severe	A
2.	Des Moines Lobe Till	slight	B
3.	Des Moines Lobe Outwash Sand & Gravel	severe	C
4.	Des Moines Lobe Valley-train Sand & Gravel	severe	D
5.	Des Moines Lobe Lake Deposit	moderate	E
6.	Superior Lobe Till	slight	F
7.	Superior Lobe Outwash Sand & Gravel	severe	G
8.	Glacial Drift, Undifferentiated	moderate	H
9.	Bedrock at or Near Surface	severe	I

In addition to the map units listed in the above table, an additional map was compiled showing the actual locations of all bedrock outcrops in Washington County. The bedrock outcrops were coded as natural outcrops (A), man-made outcrops (outcrops revealed by road-cuts or other excavations) (B), and outcrops which are partly natural and partly man-made (C). These areas of actual bedrock outcrop are comprised in item 9 of Table I.

APPENDIX 4

Guide Sheet 7 -- Soil limitation ratings for trench-type sanitary landfills 1/

Item affecting use		Degree of soil limitation		
		Slight 2/	Moderate 2/	Severe
Depth to seasonal High water table		Not class determining if more than 72 in.		Less than 72 in.
Soil drainage class		Excessively drained, somewhat excessively drained, well drained, and some 3/ moderately well drained	Somewhat poorly drained and some 3/ moderately well drained	Poorly drained and very poorly drained
Flooding		None	Rare	Occasional or frequent
Permeability 4/		Less than 2.0 in./hr	Less than 2.0 in./hr	More than 2.0 in./hr
Slope		0-15 pct	15-25 pct	More than 25 pct
Soil texture 5/ (dominant to a depth of 60 in.)		Sandy loam, loam, silt loam, sandy clay loam	Silty clay loam 6/ clay loam, sandy clay, loamy sand	Silty clay, clay, muck, peat, gravel, sand
Depth to bedrock	Hard	More than 72 in.	More than 72 in.	Less than 72 in.
	Rippable	More than 60 in.	Less than 60 in.	Less than 60 in.
Stoniness class 7/		0 and 1	2	3, 4, and 5
Rockiness class 7/		0	0	1, 2, 3, 4, and 5

1/ Based on soil depth (5-6 feet) commonly investigated in making soil surveys.

2/ If probability is high that the soil material to a depth of 10-15 feet will not alter a rating of slight or moderate, indicate this by an appropriate footnote, such as "Probably slight to a depth of 12 feet," or "Probably moderate to a depth of 12 feet."

3/ Soil drainage classes do not correlate exactly with depth to seasonal water table. The overlap of moderately well drained soils into two limitation classes allows some of the wetter moderately well drained soils (mostly in the Northeast) to be given a limitation rating of moderate.

4/ Reflects ability of soil to retard movement of leachate from the landfills; may not reflect a limitation in arid and semiarid areas.

5/ Reflects ease of digging and moving (workability) and trafficability in the immediate area of the trench where there may not be surfaced roads.

6/ Soils high in expansive clays may need to be given a limitation rating of severe.

7/ For class definitions see Soil Survey Manual, pp. 216-223.

Guide Sheet 8.--Soil limitation ratings for area-type sanitary landfills

Item affecting use	Degree of soil limitation		
	Slight	Moderate	Severe
Depth of seasonal 1/ water table	More than 60 in.	40-60 in.	Less than 40 in.
Soil drainage 1/ class	Excessively drained, somewhat excessively drained, well drained, and moderately well drained	Somewhat poorly drained	Poorly drained and very poorly drained
Flooding	None	Rare	Occasional or frequent
Permeability 2/	Not class determining if less than 2 in./hr		More than 2 in./hr
Slope	0-6 pct	6-12 pct	More than 12 pct

1/ Reflects influence of wetness on operation of equipment.

2/ Reflects ability of the soil to retard movement of leachate from landfills; may not reflect a limitation in arid and semiarid areas.

Guide Sheet 9.--Suitability ratings of soils as sources of cover material for area-type sanitary landfills

Item affecting use	Degree of soil suitability		
	Good	Fair	Poor
Moist consistence	Very friable, friable	Loose, firm	Very firm, extremely firm
Texture[1/]	Sandy loam, loam, silt loam, sandy clay loam	Silty clay loam, clay loam, sandy clay, loamy sand	Silty clay, clay, muck, peat, sand
Thickness of material (Usually uppermost part of profile)	More than 40 in. in.	20-40 in.	Less than 20 in.
Coarse fragment: percent, by volume	Less than 15 pct	15-35 pct	More than 35 pct
Stoniness class[2/]	0 and 1	2	3, 4, and 5
Slope	Less than 8 pct	8-15 pct	More than 15 pct
Drainage class (wetness)	Not class determining if better than poorly drained		Poorly drained and very poorly drained

1/ Soils having a high proportion of non-expansive clays may be given a suitability rating one class better than is shown for them in this table.

2/ For class definitions see Soil Survey Manual pp. 216-223.

APPENDIX 5

STEP 1: LOCATE INFLEXIBLE PROHIBITION AREAS

1A - Urban Development

V-07 Land Use Restrictions
2 Park
6 Developed Urban Area

1B - Shoreline

V-04 Water Orientation
1 Island
2 Meandered Lakes
4 Non-meandered Lakes
7 Meandered Streams
8 Non-meandered streams

1C - Unacceptable Surficial Geology

V-02 Surficial Geology
3 Des Moines Lobe Outwash Sand and Gravel
4 Des Moines Lobe Valley Train Sand and Gravel
7 Superior Lobe Outwash Sand and Gravel
9 Shallow Depth to Bedrock

1D - Floodplain

V-02 Surficial Geology
1 Alluvium

1E - Wetlands

V-01 Vegetation
10 Marsh
16 Open Water

1F - Steep Slopes

V-05 Slope
4 13-18 percent
5 18-30 percent
6 30 + percent

1G - Unacceptable Soil

V-06 Soil*
3,4,5,12-16,18,19,22-25,28-43,45-49
52-58

1H - Composite Map - Step 1 Conclusion

1 Urban Development
2 Shoreline
4 Unacceptable Surficial Geology
8 Floodplain or Wetland
16 Steep Slope
32 Unacceptable Soil
63 Good Sites
+ Combinations

STEP 2: FLEXIBLE PROHIBITIONS

2A - Low Density Residential

V-07 Land Use Restrictions
5 Semi-developed (1 to 4 houses per 40 acre parcel and near urban)

2B - Near Airports

V-07 Land Use Restrictions
3 Near Airports

2C - Near Parks

V-07 Land Use Restrictions
1 Near Parks

2D - Near Highways

V-08 Highway Proximity
1-14 Intersections of Major Roads
18-20 Major Roads

2F - Composite Map - Step 2 Conclusion

1 Low Density Residential
2 Near Parks
4 Near Highways
8 Near Airports
32 Prohibited - Step 1
33 No Restriction
+ Combinations

* pp. 31-2 of this report identify soil types represented here by number.

STEP 3: ENVIRONMENTAL FACTORS

3A - Intermittent Streams

V-03 Water Orientation #9

3B - Soil; Moderate Limitations

V-06 #2,26,50,51

3C - Geology; Moderate Limitations

V-02 5,8

3D - Vegetation

V-01 1,2,8,9,13,14,15

3E Planned Future Development

V-07 Land-Use #3

<u>3F - Composite Map - Step 3 Conclusion</u>

1 Soil
2 Geology
4 Vegetation
8 Intermittent Streams
16 Future Development
32 Prohibited Steps 1 & 2
33 No Prohibition
\+ Combinations

STEP 4: COST - LAND USE FACTORS

4A - Municipal Wells and 1 mile perimeter

V-09 1,4

4B - Private Wells and 1 mile perimeter

V-09 2,5

4C - Multiple Private Wells and 1 mile perimeter

V-09 3,6

4D - Haul Distance from 694

V-16

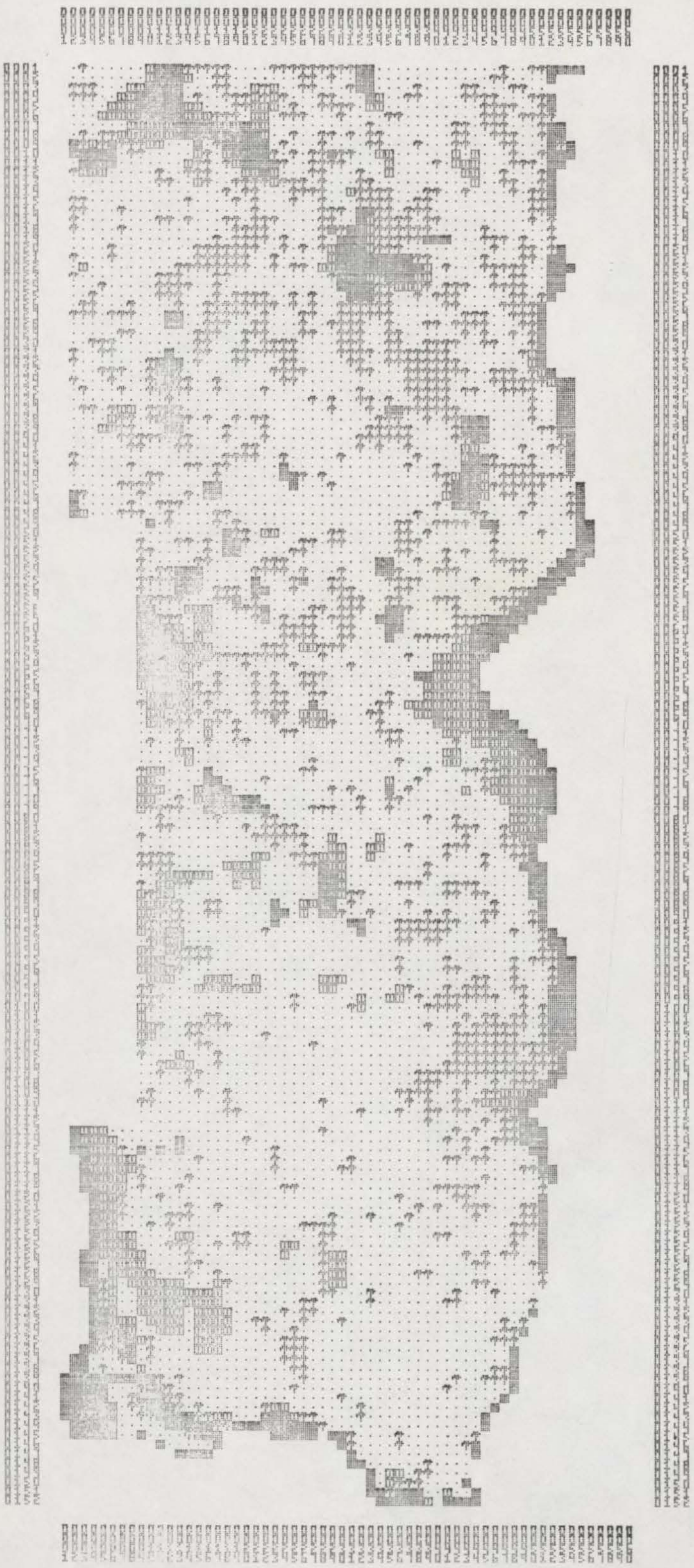
4E - Accessibility High Axle Limit Road

V-32

4G - Composite Map - Step 4 Conclusion

1 Municipal Wells
2 Private Wells
4 Haul Distance
8 Axle Weight Limits
32 Prohibited
33 No Prohibitions
\+ Combinations

APPENDIX 6



V-1 VEGETATION

:::: Allowable

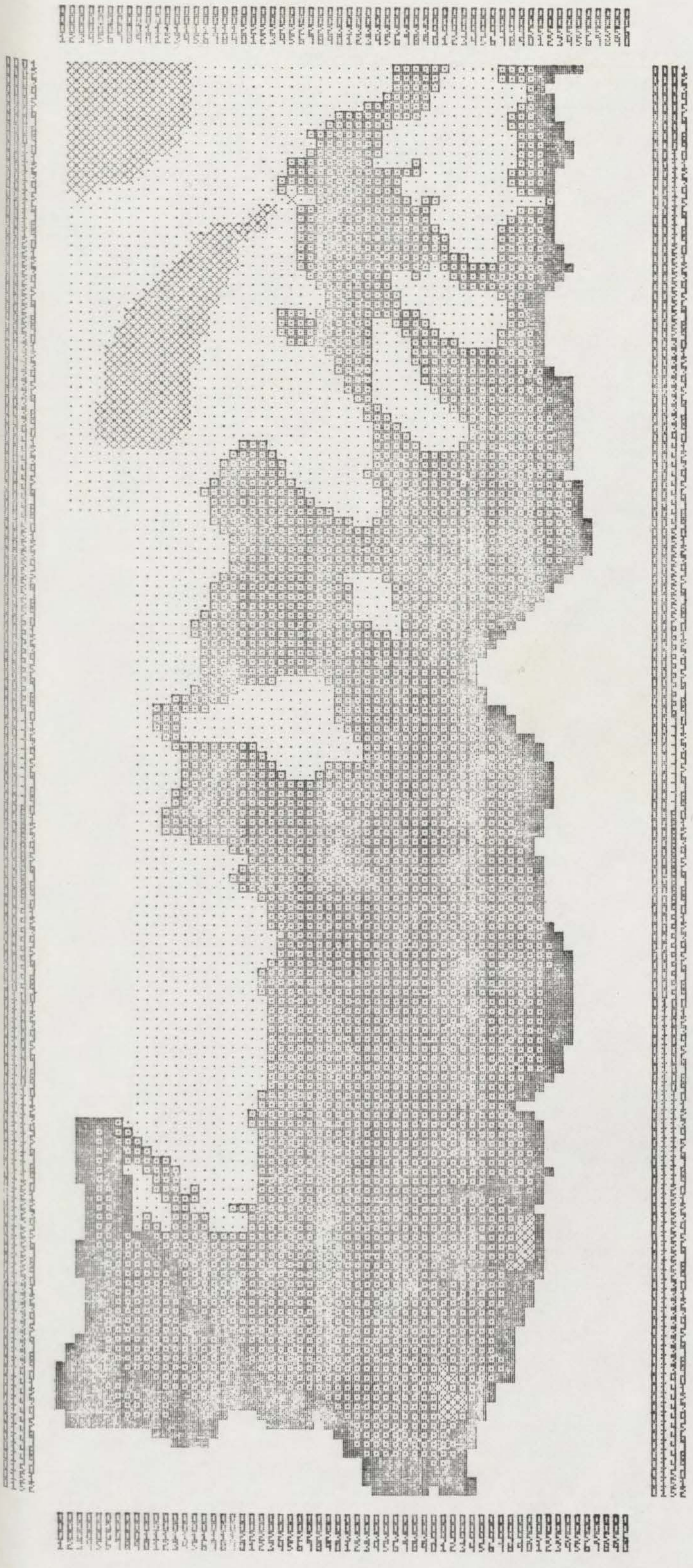
Wooded (Step 3)

Urban

Water-Wetlands

Source: Ecological inventory
McHarg
Scale: 1" = 5 miles
North:

WASHINGTON COUNTY
SOLID WASTE DISPOSAL
SITE SELECTION STUDY

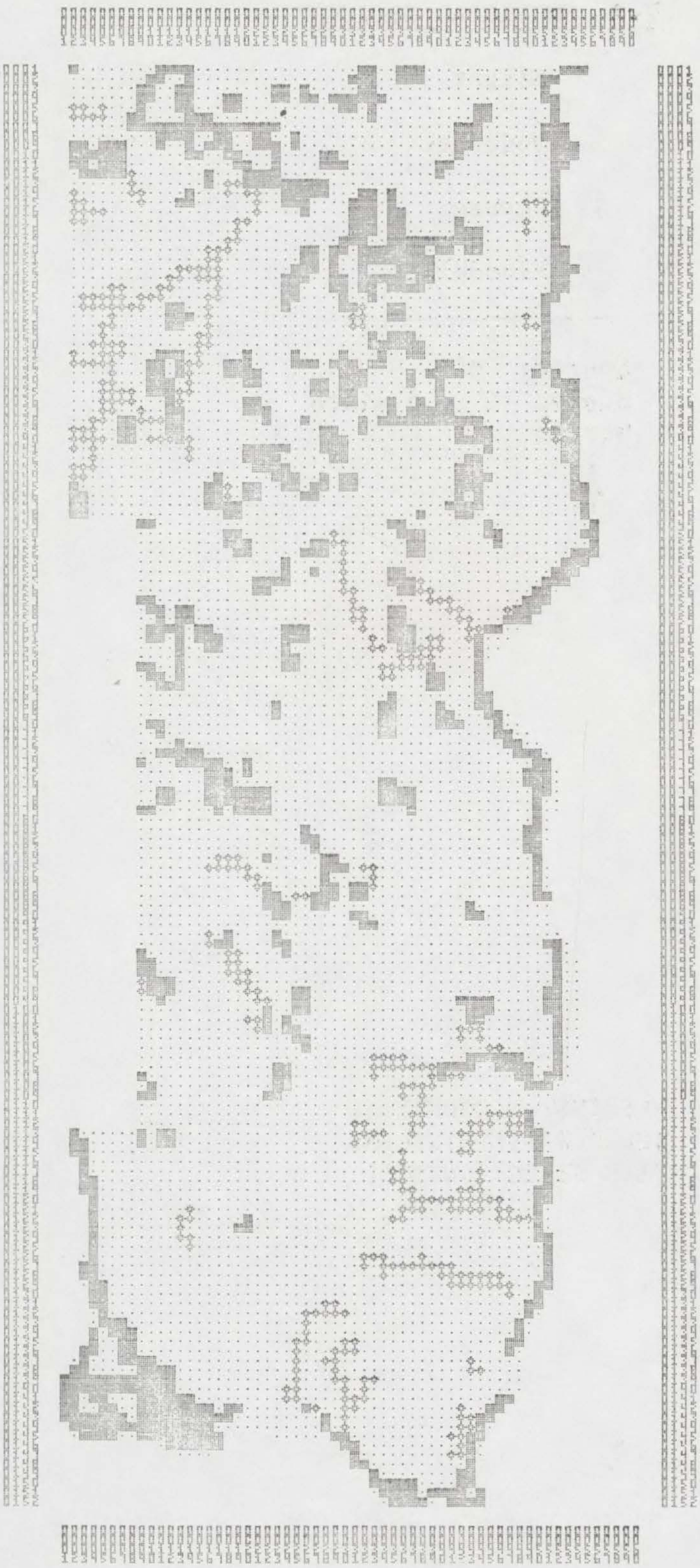


V-2 SURFICIAL GEOLOGY

- Slight
- Moderate
- Severe
- Floodplain

Source: MGS
Scale: 1" = 5 miles
North: ↑

WASHINGTON COUNTY
SOLID WASTE DISPOSAL
SITE SELECTION STUDY



V-4 WATER ORIENTATION

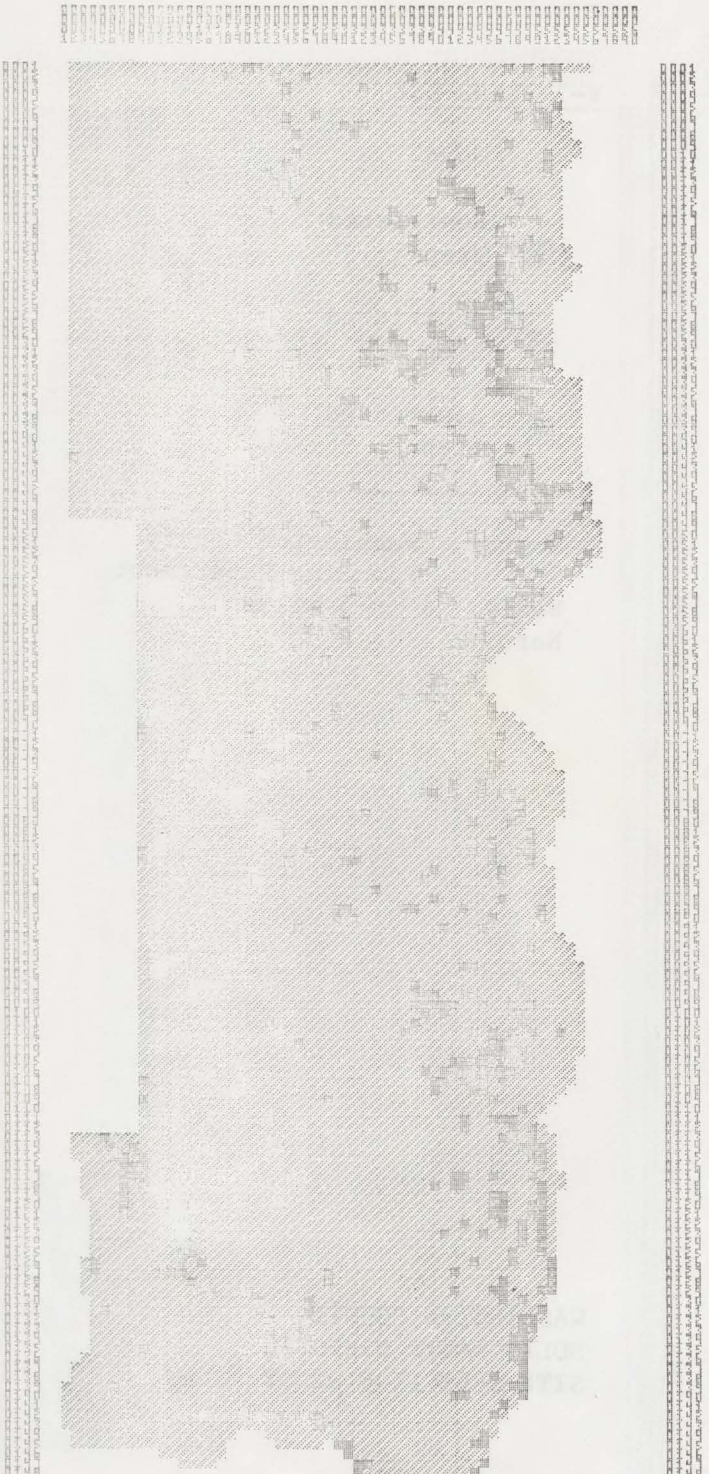
Open

Step 1

Step 3

Source: MLMIS Data
Scale: 1" = 5 miles
North:

WASHINGTON COUNTY
SOLID WASTE DISPOSAL
SITE SELECTION STUDY



V-5 SLOPE

0-13%

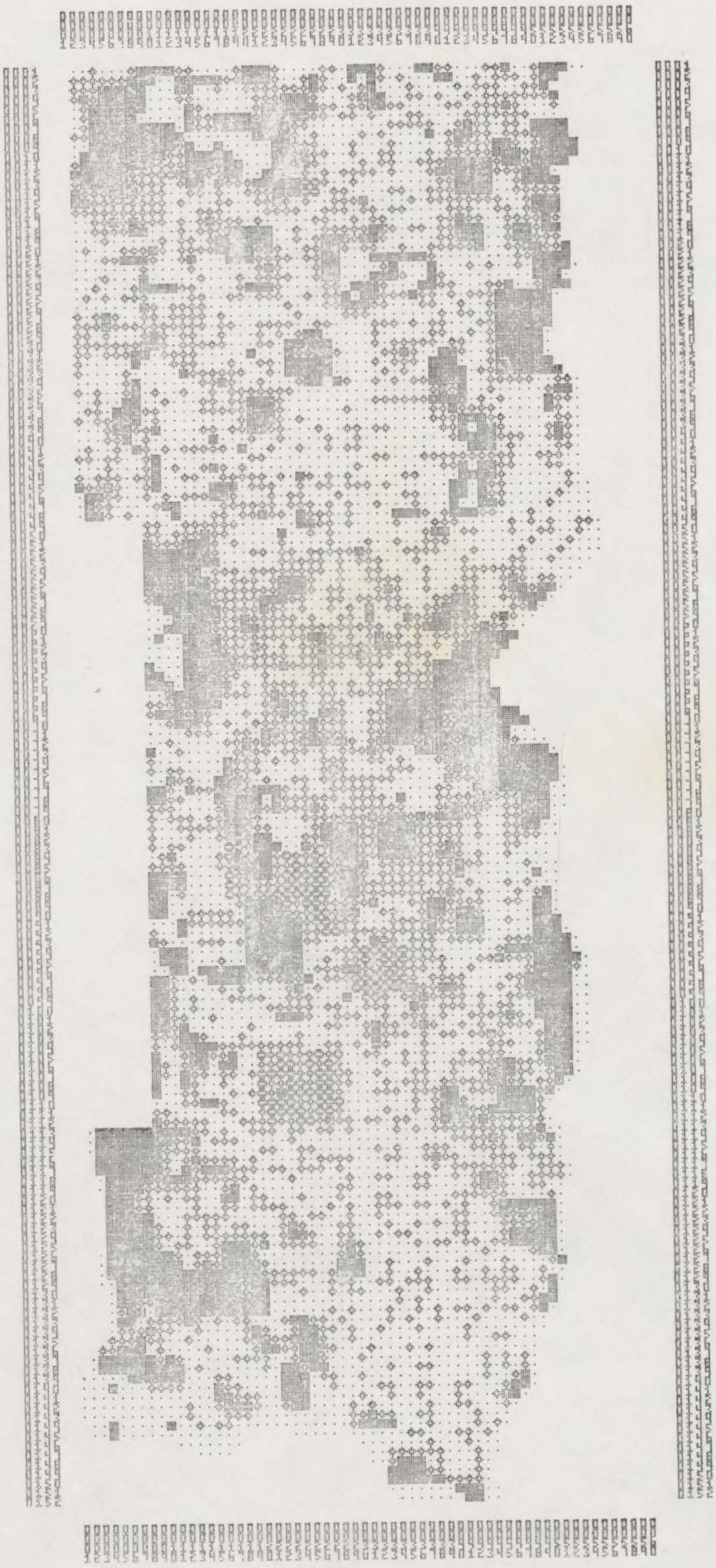
13% +

Source: SCS County Soil Survey

Scale: 1" = 5 miles

North:

WASHINGTON COUNTY
SOLID WASTE DISPOSAL
SITE SELECTION STUDY



V-7 LAND-USE

Open

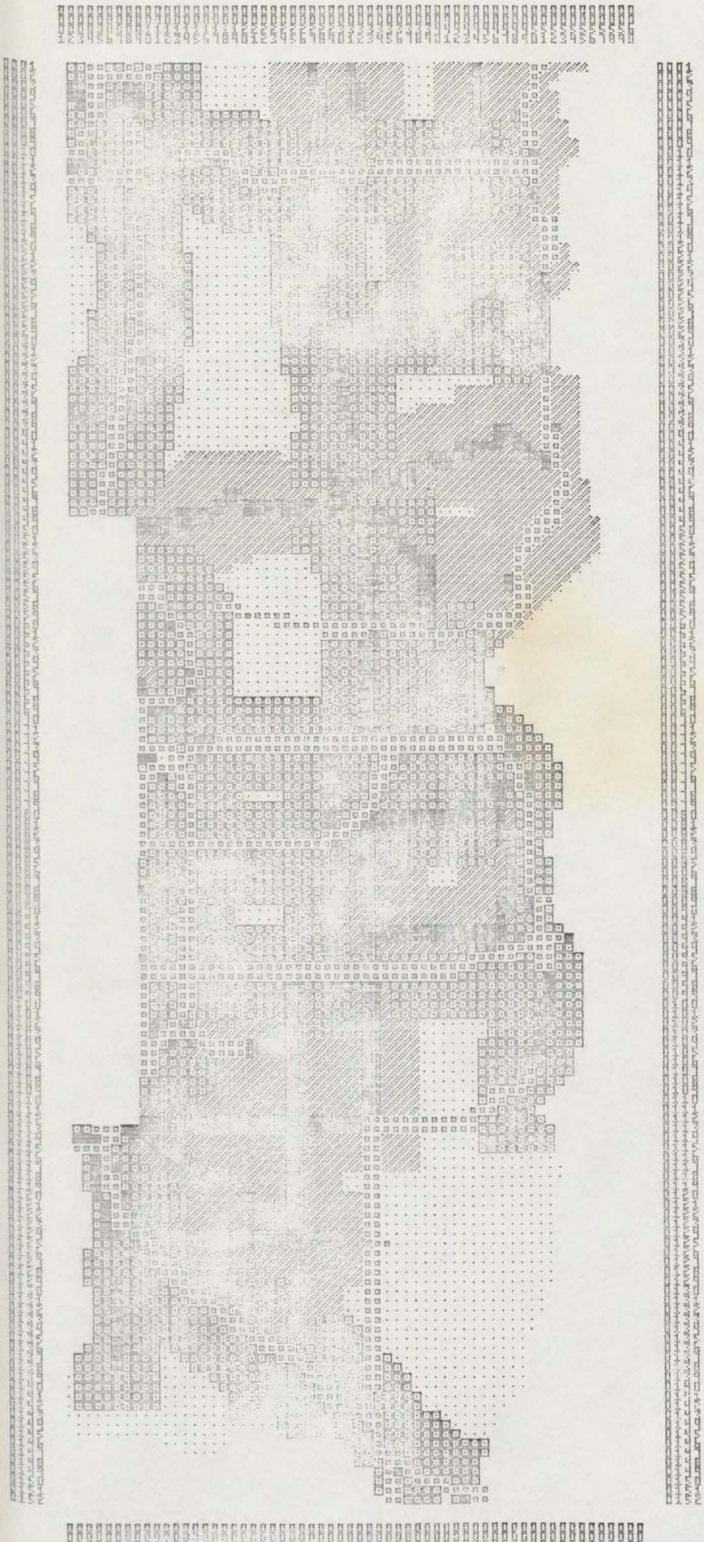
Restricted
Step 1

Restricted
Step 2

Restricted
Step 3

Source: Washington County
Planning Department
Scale: 1" = 5 miles
North:

WASHINGTON COUNTY
SOLID WASTE DISPOSAL
SITE SELECTION STUDY



V-32 NEAR AXLE LIMIT ROADS

Open Land

9-Ton Road

7-Ton Road

Near 9-Ton Road

Near 7-Ton Road

State or Federal Road

Source: Washington County
Highway Department

Scale: 1" = 5 miles

North:

WASHINGTON COUNTY
SOLID WASTE DISPOSAL
SITE SELECTION STUDY